(1926) and Gaede's Catalogue (1937) are the most important; Benander's paper on the Swedish species (1928) also deserves mention here. In Oecophoridae, Meyrick's revision (Wytsman 1922); Turner's present revision of the Australian species has already been referred to. In Aegeriadae, Beutenmuller's Monograph of the Sesiidae of N. America (1901), the Catalogue by Dalla Torre and Strand (1925), Le Cerf's important contributions in Oberthür's *Et. Lep. comp.* and other publications, Hampson's revision of the African and Oriental species, and the articles in Seitz' Macrolepidoptera. Revisions in Wytsman's Genera Insectorum and Catalogues of the Families have also been published by Meyrick for the Carposinidae, Heliodinidae, Glyphipterygidae, Gracilariadae, Adelidae and Micropterygidae, and Catalogues only of the Yponomeutidae, Plutellidae and Amphitheridae. Wagner and Pfitzner have also issued a Catalogue of the Hepialidae (1914) (also articles in Seitz), and Tutt (Brit. Lep. I: 1899) gave a detailed account of the British Stigmellidae (Nepticulidae).

The above brief and necessarily very incomplete account may serve to show that active progress in Microlepidopterology has taken place during the last half-century. Even in the best-worked countries, however, new species still turn up and many life-histories and other details remain to be elucidated; in the remainder of the world, however, the greater part of its Microlepidopterous fauna is still to be discovered.

SOME CHANGES IN OUR OUTLOOK ON VARIATION.

E. A. Cockayne, D.M., F.R.C.P.

It is impossible in a few pages to review the great progress made in Entomology in the last fifty years. No more can be attempted than to show how the advances in knowledge have changed our outlook on some of the problems that interested our founder. Of the period when this journal was started Bateson was able to write with truth "the terms 'variation' and 'heredity' stood for processes so vague and indefinite that no analytical investigation of them could be contemplated." The way to a more precise understanding of variation and heredity and of the nature of species and subspecies was not opened until Mendel's paper was rediscovered in 1900. Proof that segregation of characters occurred in animals as well as in plants soon followed and it was shown that many mutant forms were determined by a single gene and were either dominant or recessive to the normal form. The phenomenon of reversion, so puzzling to Darwin, was explained, for forms that reverted to the normal were recessive. They were not lost, but were rendered latent, and if members of the F_1 generation were crossed *inter se* they reappeared in the ratio 1:3. Many rare aberrations of butterflies and moths regarded by contributors to our early numbers as meaningless sports or freaks are no doubt rare recessives, though in most cases proof of this is still lacking.

As time went on it was shown that, though the obvious effect of a gene might be only a striking alteration in colour or pattern, it had subtle but far-reaching effects on the constitution of the whole organism. It was also found that in a mutant form determined by a single gene considerable variation occurred and that this was due to the modifying effect exerted by other genes, as Onslow in 1921 showed to be the case in *Diaphora mendica.* Here the white Irish male, ab. *rustica,* is dominant to the brown English male, but many buff forms exist and are due to the presence of modifiers. In *Spilarctia lutea* and its ab. *zatima* two modifiers causing increased radiation are present, but in some cases many genes contribute to the modifying effect and it is then said to be due to the gene complex.

Sex-linked inheritance was discovered in 1908 by Leonard Doncaster in the course of his breeding experiments with *Abraxas grossulariata,* ab. *lacticolor,* and was found to depend upon the fact that in the female there are two dissimilar chromosomes, X and Y, and in the male two similar ones X. The *lacticolor* character was found to be recessive and carried in the X-chromosome. This discovery has led to a better understanding of sex determination, not only in insects, but in vertebrates as well. Later it was found that in *Drosophila* the sex chromosomes of the male are XY and of the female XX. Largely owing to the work of Goldschmidt, it is now known that sex is largely dependent on male and female factors, the factor for maleness in *Lymantria* lying in the X-chromosome and that for femaleness in the cytoplasm. The valency of the X-chromosome differs in different races and species, that of *Smerinthus ocellatus* being so much greater than that of *Amorpha populi* that in the hybrid *hybridus* females are transformed into males or intersexes.

In his " Origin of Gynandromorphs " (1919) Morgan showed that in *Drosophila* most gynandromorphs are caused by the loss of an X-chromosome at the first cleavage of the fertilised ovum or at some subsequent division. Some gynandromorphs in Lepidoptera are produced in the same way, but knowledge of which characters are sex-linked and which are not has shown that many cannot be due to this cause and cytological investigation has proved that they originate through the fertilisation of each nucleus of a binucleate ovum by a separate spermatozoon. In *Bombyx mori* and *Argynnis paphia* the females that lay binucleate ova are recessive, and of the former species thousands of gynandromorphs have been bred. Facts, which were quite obscure in Tutt's day, such as the frequency of gynandromorphs in some species and their rarity in others and the occurrence of gynandromorphs of a species again and again in one locality, of *Polyommatus icarus* in Sligo for example, can now be readily explained.

Tutt's book on Melanism and Melanochroism (1891) testifies to his interest in this subject. Since his day melanic forms of many species of Lepidoptera, some occurring in the larva and others in the imago, have been discovered. Many of these may be new mutations, but whether new or not, there can be no doubt that some have become much commoner and have greatly extended their range, and the association of melanism with industrial centres both in this country and on the continent is indisputable.

Harrison and Garrett claim that they have produced melanic mutations by means of manganese suphate in the food of the larva and Hasebrouck claims to have done likewise by means of other chemicals. Attempts by McKenny Hughes and Lampke to confirm the results obtained by Harrison and Garrett with *Selenia bilunaria* failed, but Harrison thinks this is accounted for by the high mortality in their broods. He says that melanic *bilunaria,* a recessive, is less hardy than the normal form and, if the death rate is high, any melanic mutations obtained are likely to die before reaching maturity. Other critics have said that Harrison's results show an incredibly high mutation rate. It is true that high rates of mutation have been obtained in *Drosophila* by means of X-rays, but these mutations are for the most part grossly pathological, and it is now known that they are due to translocations and dislocations of the chromosomes. They are not comparable with the gene mutations resulting in physiological changes in colour and pattern, the class to which melanic mutations belong. Ford (1938) suggests that though industrial areas may be centres of melanism they do not necessarily cause it. He believes that most moths from time to time produce a melanic mutation, which may increase its numbers and range if the environment suits it. It is indeed surprising in what a high proportion of species a melanic form has been recorded. Some of them are very rare and others very local, but many have been found in rural areas. It has been shown by breeding experiments that some melanic forms, such as *Biston betularia* ab. *carbonaria*, *Boarmia rhomboidaria* ab. *rebeli*, and *Hemerophila abruptaria* ab. *fuscata*, are constitutionally stronger than the normal forms, and this explains in part why melanic *betularia* has continued to spread and has nearly superseded the typical form in localities far removed from its place of origin. In industrial areas many melanic mutants are better protected by day, especially those that rest on tree trunks, and there is some evidence that they are caught less often by bats, one of the great enemies of nocturnal moths. The combined effect of these advantages may be considerable and fully account for the rapid increase in melanism in some species. On the other hand, some melanic forms, such as *Selenia bilunaria*, are less hardy, and others, such as the black forms of *Papilio machaon*, *Arctia caia*, and *Callimorpha dominula*, are only just viable and remain great rarities.

Aplecta nebulosa, in addition to its extreme melanic form, ab. *thompsoni*, has a graded series of dark forms, which are probably multifactorial, several genes for increased pigmentation existing, and many other examples of this kind could be adduced, amongst them *Xylophasia monoglypha* and *Erannis leucophaearia*.

Apart from major mutations, minor hereditable mutations occur and arise more frequently. These are of the greatest importance in evolution. Possibly new surroundings may induce them, but in any case, if the environment is different, those which are in any way advantageous will be favoured. Hence the spread of a species to a new area or a change of conditions in part of its existing range will lead to the formation of a new race differing from the old in a number of genetic characters. Complete isolation over a long period will lead to more and more differences until a subspecies is formed, and later still the differences may become sufficiently numerous and important for it to be regarded as a distinct species. This is probably the usual way by which a new species originates in the Lepidoptera.

The work of Goldschmidt and his pupils on *Lymantria dispar* shows what profound physiological differences may occur in a species, which is comparatively constant in external appearance, in the various parts of its geographical range. As he points out few of these differences could be detected by a taxonomist, though many of them are of great biological importance.

Parallel variation, when this journal was founded, was merely an interesting fact to record, and though regarded as a proof of relationship or of common ancestry its significance was not fully understood. The wonderful work of the American school on *Drosophila*, which has enabled chromosome maps to be made showing not only the chromosome in which the gene for a given character is carried but the exact locus on that chromosome, has helped to explain it. It has been shown that the gene for a similar character occurring in two allied species of *Drosophila* may be carried at the same locus of the same chromosome and may in the hybrid behave as in the pure species. In other words, the character is not merely a similar character, but is the same character and the gene determining it is identical in both species. This is to some extent a corollary to the genetic explanation of the origin of races, subspecies, and species. Closely allied species have a great number of genes in common and the same mutant gene may occur in several of them. The white form of female, which is found in most species of *Colias* and has proved to be a sex-limited dominant in those investigated, is probably determined by the same gene derived from the common ancestor of them all. There is, however, the possibility that a gene may mutate in the same way in two allied species after they have become specifically distinct, just as the same gene mutation may occur more than once in the same species. The recessive melanic mutations of *Ennomos autumnaria* and *E. quercinaria* are rare and local and probably originated independently. This is supported by the fact that in some of the allied species no similar aberration is known. At present there is no proof that the melanic mutation in these two species is the same, but, since they hybridize, proof or disproof could be obtained by a suitable pairing.

At present there is a tendency to regard all variation as genetic and the present generation pays little attention to the work of Merrifield. Environmental conditions, however, can alter the colour and even the pattern of many butterflies and of some moths. High temperature will produce a lighter colour in both northern and southern races of *Lasiocampa quercus*, and low temperature will cause a darkening of colour in the southern race. These results are probably brought about in the same way as in *Heliothis peltigera*. Kettlewell's experiments have shown that in this species the shorter the period of development in the pupa the lighter the colour of the imago and the longer the period of development as opposed to the duration of the pupal stage the darker the colour. Thus environment can produce extremely pale or dark moths from pupae of the same genetic constitution. There can be little doubt that variation of this kind is not uncommon in some species under natural conditions.

Tutt collected most of the available information about hybrid Lepidoptera, but very large numbers of new hybrids have been bred during the last fifty years and cytological study of the behaviour of the chromosomes in various hybrids had not even begun while he was living. The view that a cross between two species could not produce a fertile hybrid is no longer accepted, although it is true that most hybrids are infertile. Recent work on the hybrid hawk moths has proved that in some cases hybrids are fertile and can even give a secondary hybrid with a third species. These hawk moths all have the same number of chromosomes and, where this is so conjugation of corresponding chromosomes derived from each parent is much more complete and fertility more probable than it is when the chromosome numbers differ. Some hybrid Bistoninae and Saturniidae also show partial fertility and secondary hybrids have been bred in large numbers. Thus, one of the criteria accepted as proof of specific rank when the journal was founded is now known to be invalid.

Progress during the last half-century has been phenomenally rapid and has taken place in many unexpected directions, but it has been dependent to a great extent on the belated recognition of Mendel's Law. One wonders whether there will be any discovery so fundamental as that of Mendel to record when the next fifty years are over and our journal celebrates its centenary.

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THE GRADUAL CHANGE IN THE LONGTIME INSULAR OUTLOOK OF THE BRITISH ENTOMOLOGIST.

By Rev. Geo. Wheeler, M.A., F.R.E.S.

The collecting and study of foreign insects by British entomologists, especially as influenced by the *Ent. Rec.*, being the subject assigned to me for our Jubilee Number, I naturally started by finding out what had been done in this direction before the publication of our magazine began. The earliest mention of anything of the kind which I have found is in the 1st Vol. of the *Entomologist* (1841), but this consists only of a few notes by Doubleday from the U.S.A. and a list by Gosse from a part of Canada. When its publication was resumed in 1864 a few more foreign lists occur but mostly from far distant lands, and there is hardly anything approaching an account of a "collecting expedition" for several years, in fact, till the Rev. Dr F. A. Walker began his account of his entomological wanderings in 1875, but even these are hardly in the style of later accounts. A few more entomologists, such as Mr W. E. Nicholson (Switzerland, 1885), Mr Norris (French Riviera, 1889), and Mrs Nicholl (Digne, 1890) gave more lively accounts, but they were few and far between. Such records in the *E.M.M.* are even fewer. Dr White on N. Italy in 1867 is the earliest I have found. A few names which appear later in the *Ent. Rec.* also occur in the *E.M.M.* Mr Bethune-Baker wrote on Algeria in 1886 and subsequently on French, Italian, and Swiss localities, and Mr A. H. Jones on some of the same localities in 1886; Messrs Nicholson and Lemann also wrote on their expedition in the Pyrenees in 1894, but this was after the beginning of the *Ent. Rec.*